



Engineer Research and
Development Center

Introduction to GenCade

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Outline

- What is GenCade?
- Background, overview, and conceptual coverage
- GenCade capabilities
- GenCade limitations and assumptions
- Workflow
- Model theory and formulation
- I/O Files and Cards



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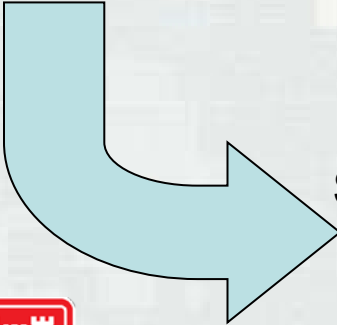
GENESIS + Cascade → GenCade

Cascade (top to bottom)

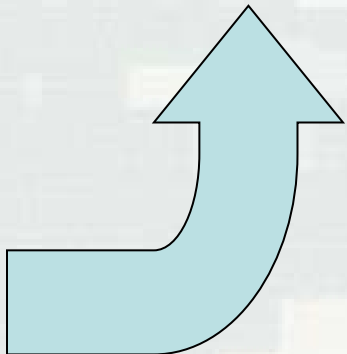
- Planning tool (RSM Support)
- Time scales: months to centuries
- Multiple inlets, shoals, and barrier islands; cumulative impacts; retains curvature of regional geomorphology
- Fast
- Typical grid resolution ~ 500 m

GENESIS (bottom to top)

- Engineering design tool
- Can represent all engineering details – structures, etc.
- Mature technology – big payback by updating
- Typical grid resolution ~ 25 m



Strategy: Add Cascade capabilities to GENESIS to automatically include all GENESIS features



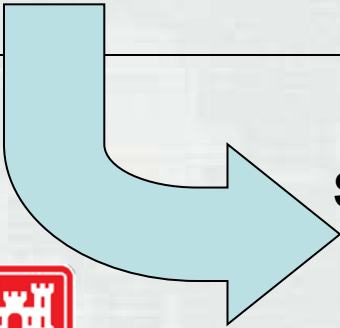
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GENESIS + Cascade → GenCade

- Integrate from planning through engineering design
- Cover time scales from one year to centuries
- Preserve regional trends
- Furnish regionally consistent boundary conditions to local projects
- Represent cumulative local projects interacting regionally
- Represent inlet bypassing and tidal delta evolution
- Resolve engineered elements
- Include variable grid resolution for accuracy and efficiency
- Improve computational efficiency (over GENESIS)



Strategy: Add Cascade capabilities to GENESIS
to automatically include all GENESIS features



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GenCade Conceptual Processes: Coastal Sediment Dynamics

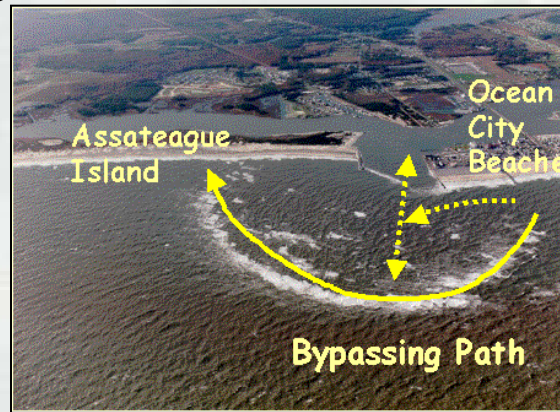


GenCade Applicability

Regional processes, Long-term morphology change



Project Planning & Design



Habitat Change



- Regional Sediment Management
 - Beach fills
 - Inlet bypassing
 - Channel maintenance
- Unifying technology for multiple projects
- Intuitive interface (SMS)



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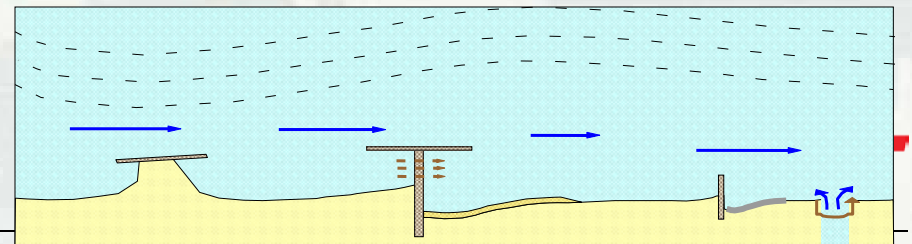
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Model Functionality and Capabilities

- Variable resolution grids
- Inlet bypassing
- Inlet Reservoir Model for calculation of shoal and inlet feature sediment balance
- Representation of regional morphologic trends
- Multiple wave input forcing locations
- Representation of coastal structures: groins, jetties, seawalls, t-head groins, breakwaters, etc.
- Calculation of salients and tombolos behind breakwaters
- Time-dependent detached breakwater transmission
- Efficient calculation of breaking wave properties in internal wave model



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GenCade Assumptions

- Beach profile maintains a constant average shape
- Longshore transport occurs only between top of berm and depth of closure (or active transport)
- Sand transported alongshore by breaking waves is not affected by nearshore current patterns
- There is a long-term trend in shoreline evolution
- The detailed structure of the nearshore circulation is ignored



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General Workflow

- Coastal Problem
 - Formulate question
 - Identify constraints
 - Develop criteria to review and evaluate the solutions
- Assemble and analyze relevant input data
- Develop engineering solutions and alternatives
- Develop and execute GenCade to optimize project solutions and alternatives
- Calibrate, Validate, Evaluate Alternatives
- Evaluate results



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GenCade Workflow

- Compile project data
- Assimilate data as GenCade forcing or BC input
- Develop conceptual model from input data
- Develop GenCade project grid and alternatives

Pre-
Process

- Execute calibration simulations/sensitivity tests
- Review and analyze calibration results
- Refine setups
- Execute production simulations

Simulate

- Review results
- Analyze and post-process results

Post-
Process



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GenCade Workflow

Inputs:

Survey data
Waves
Structure information
Inlet information
Beach Fill
Dredging

**Pre-process
inputs**

**GenCade grid
regular/irregular**

Develop initial shoreline

Develop regional contour

Assign wave inputs

Supply input control parameters

Structures or coastal projects

Inlets, shoals, dredging events

Beach fill events

Simulation outputs:
GenCade solution files



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GenCade Workflow

Inputs:

GenCade Solution files;
Measured Data

Post-process

Transport rates

Sediment budgets

Shoreline Change

Inlet bypass/shoal evolution

Compare measured

Compare alternatives

Post-process outputs:
Calculations, figures,
images, exported data



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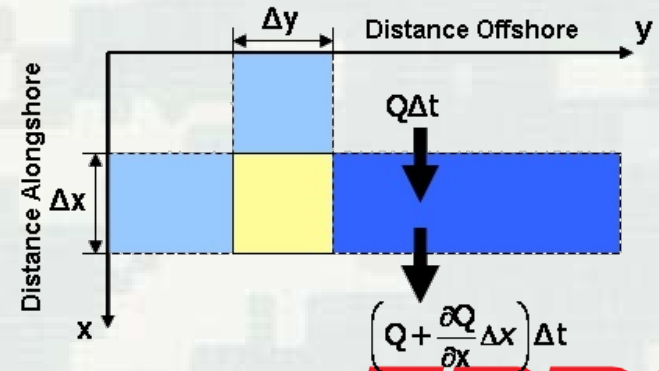
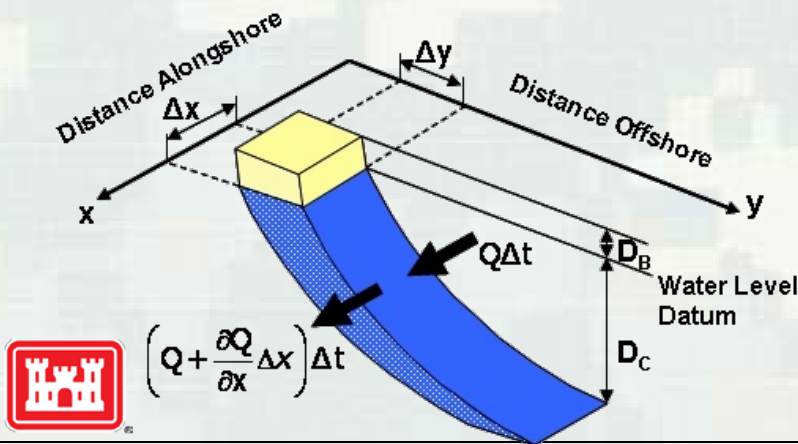
Model Formulation

Longshore Net Volume Change:
$$\frac{dQ}{dt} = \left(\frac{\partial Q}{\partial x} \right) dx dt$$

Cross-shore Net Volume Change:
$$dq dt$$

Total Volume Change:
$$dV = dx dy (D_B + D_C) = \left(\frac{\partial Q}{\partial x} \right) dx dt + q dx dt$$

$$\therefore \text{as } dt \rightarrow 0: \frac{\partial y}{\partial t} + \frac{1}{D_B + D_C} \cdot \left[\frac{\partial Q}{\partial x} - q \right] = 0$$



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Model Formulation

Sediment transport rate Q (m^3/s):

$$Q = \left(H^2 C_g \right)_b \left(a_1 \sin 2\alpha_{bs} - a_2 \cos \alpha_{bs} \frac{\partial H_b}{\partial x} \right)$$

Where,

H = wave height (m)

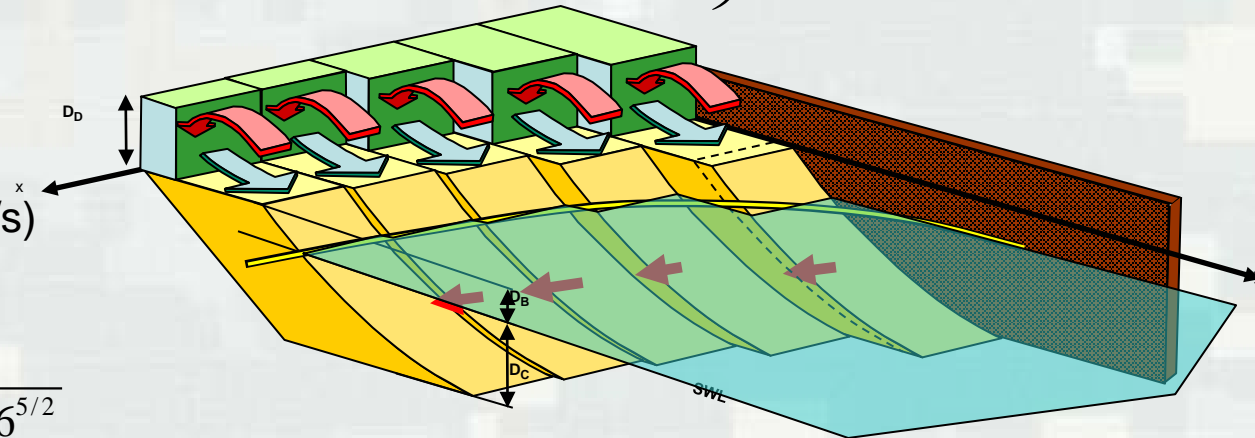
C_g = wave group speed (m/s)

α_{bs} = angle of the breaking

$$a_1 = \frac{K_1}{16(\rho_s / \rho - 1)(1 - p) 1.416^{5/2}}$$

$$a_2 = \frac{K_2}{8(\rho_s / \rho - 1)(1 - p) \tan \beta 1.416^{5/2}}$$

Typically, value of K_2 is:
 $0.5K_1 < K_2 < 1.5K_1$



Where,

K_1 = Primary empirical transport coefficient
 (controls magnitude of longshore transport rate)

K_2 = Secondary empirical transport coefficient
 (controls distribution of sand within an area; esp.
 where large wave height gradients, e.g. salients)

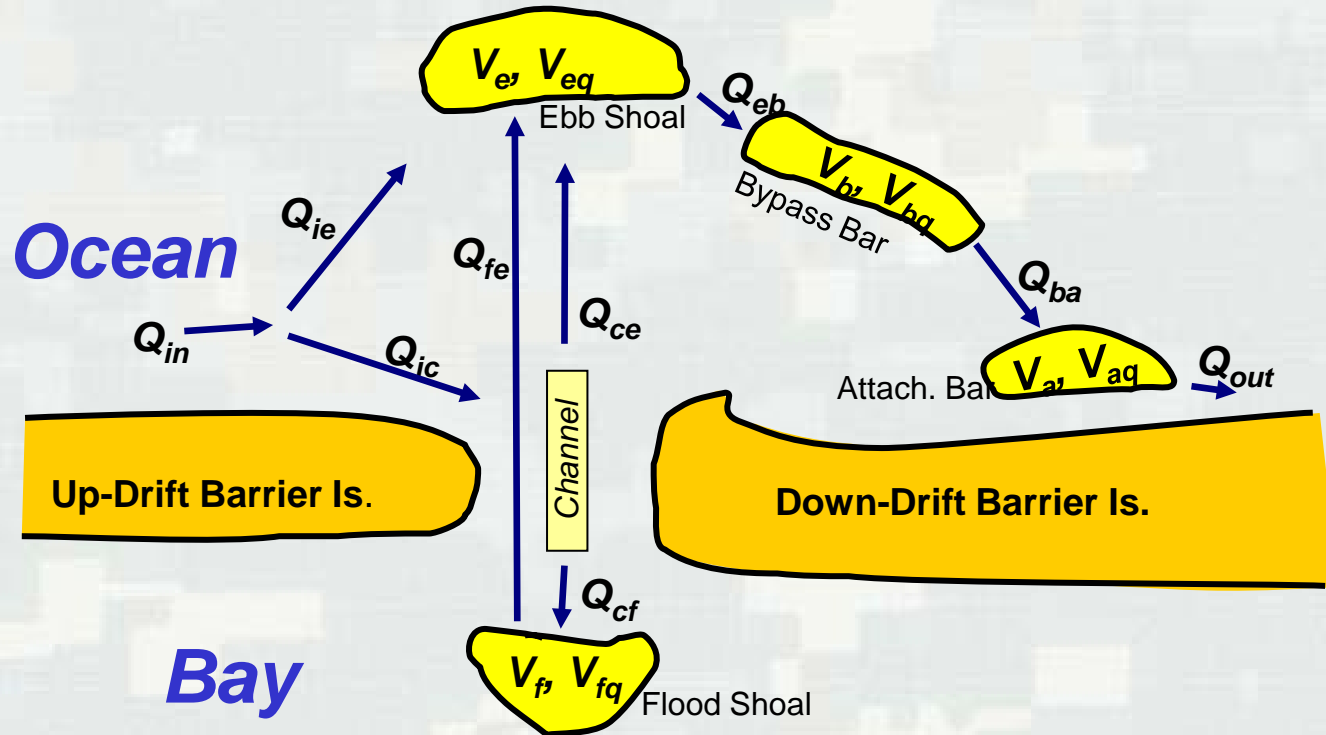
$\tan \beta$ = average bottom slope

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Inlet Reservoir Model

Inlet bypassing and evolution of inlet deltas



$$Q_{ie} = \delta Q_{in}$$

$$Q_{ic} = (1 - \delta) Q_{in}$$

$$Q_{ce} = \beta Q_{ic} = \beta (1 - \delta) Q_{in}$$

$$Q_{cf} = (1 - \beta) Q_{ic} = (1 - \beta) (1 - \delta) Q_{in}$$

$$Q_{fe} = (V_f - V_{fq}) / dt, V_f > V_{fq}$$

$$Q_{eb} = \frac{V_e}{V_{eq}} (Q_{ie} + Q_{fe} + Q_{ce})$$

$$Q_{ba} = \frac{V_b}{V_{bq}} Q_{eb}$$

$$Q_{out} = \frac{V_a}{V_{aq}} Q_{ba}$$

$$\delta = (V_e + V_f) / (V_{eq} + V_{fq})$$

$$dV_e = (Q_{ie} + Q_{fe} + Q_{ce} - Q_{eb}) dt$$

$$dV_f = (Q_{cf} - Q_{fe}) dt$$

$$dV_b = (Q_{eb} - Q_{ba}) dt$$

$$dV_a = (Q_{ba} - Q_{out}) dt$$

$$\beta = (1 - V_e / V_{eq}) / (2 - V_e / V_{eq} - V_f / V_{fq})$$



Output File Format for GenCade

Instantaneous Net Transport at Output Time (*.qtr) File

Column 1	Column 2 through Column NX
Date (yyyymmdd)	Net sediment transport (length ³ /year) for each grid cell

Mean Net Transport Over Simulation or Specified Time (*.mqn) File

Column 1	Column 2 through Column NX
Date (yyyymmdd)	Net sediment transport (length ³ /year) for each grid cell averaged over entire simulation (and optionally from start to specified times)

Mean Left Transport Over Simulation or Specified Time (*.mqL) File

Column 1	Column 2 through Column NX
Date (yyyymmdd)	sediment transport (length ³ /year) to left for each grid cell averaged over entire simulation (and optionally from start to specified times)

Mean Right Transport Over Simulation or Specified Time (*.mqR) File

Column 1	Column 2 through Column NX
Date (yyyymmdd)	sediment transport (length ³ /year) to right for each grid cell averaged over entire simulation (and optionally from start to specified times)



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Output File Format for GenCade

Shoreline Position at Output Time (*.s/o) File

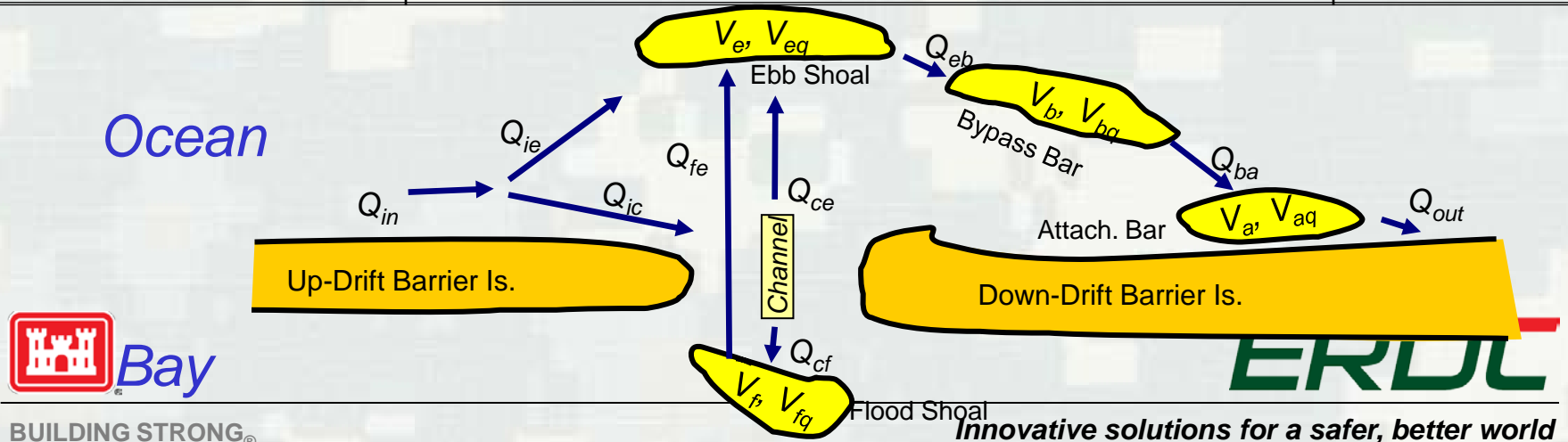
Column 1	Column 2 through Column NX
Date (yyyymmdd)	Y-position of shoreline (length unit) for each grid cell

Calculated Offshore Contour at Output Time (*.off) File

Column 1	Column 2 through Column NX
Date (yyyymmdd)	Y-position of offshore contour applied to wave transformation (length unit) for each grid cell

Inlet Shoal Volume Output (*.irv) File (one file for each inlet)

Column 1	Column 2 Through Column 16	Column 17
Time-step at which shoal volumes are printed as output	Shoal volume (length ³) or in /.out volume at each shoal output time-step for the morphological shoal features identified in the figure below	Date (yyyymmdd)



GenCade Input Cards

- **TITLE** Title of simulation run
- **INIFILE** Path and name of initial shoreline file
- **REGFILE** Path and name of regional shoreline file
- **NUMWAVES** Number of wave input locations/files
- **WAVEID** Cell ID; Depth; number of wave events; and file path/name of wave input data (1 WAVEID line/file)
- **PRFILE** Path and name of printed output file
- **GENUNITS** (ft) or (m) System of units for model I/O
- **X0** X-origin
- **Y0** Y-origin
- **AZIMUTH** Angle (deg) of grid rotation about origin
- **NX** Number of alongshore cells
- **DX** Cell resolution or -1 indicates variable resolution
- **SIMDATS** YYYYMMDD Start date of simulation
- **SIMDATE** YYYYMMDD Ending date of simulation
- **DT** 1.0 Time step in hours
- **DTSAVE** 10.0 Data (shoreline/transport) output times
- **K1** 0.5 Longshore sediment transport coefficient 1
- **K2** 0.25 Longshore sediment transport coefficient 2
- **PRTOUT** Output to PRFILE yes (t), no (f)
- **PRWARN** Print warnings yes (t), no(f)
- **PRDATE** Dates to save simulated shoreline
- **ISMOOTH** 11 #cells in offshore contour smoothing
- **IREG** Include regional contour (1 = yes; 0 = no)
- **HAMP** 1.0 Height amplification factor
- **THETAAMP** 1.0 Angle amplification factor
- **THETADEL** 0.0 Angle offset
- **LMOVY** 0.0 Leftward shoreline displacement velocity
- **D50** 0.33 Grain size diameter in millimeters
- **BERMHT** 2 Average berm height
- **DCLOS** 8 Depth of closure
- **LBCTYPE** 0 Left boundary condition type
- **LMOVY** 0.0 Leftward shoreline displacement velocity
- **LMOVPER** 1 Simulation period (0), day(1), time step (2) period for LMOVY
- **LGROINY** 0.0 Length of left groin from shoreline to seaward tip
- **RBCTYPE** 0 Right boundary condition type
- **RMOVY** 0.0 Rightward shoreline displacement velocity
- **RMOVPER** 1 Simulation period (0), day(1), time step (2) period for RMOVY
- **RGROINY** 0.0 Length of right groin from shoreline to seaward tip



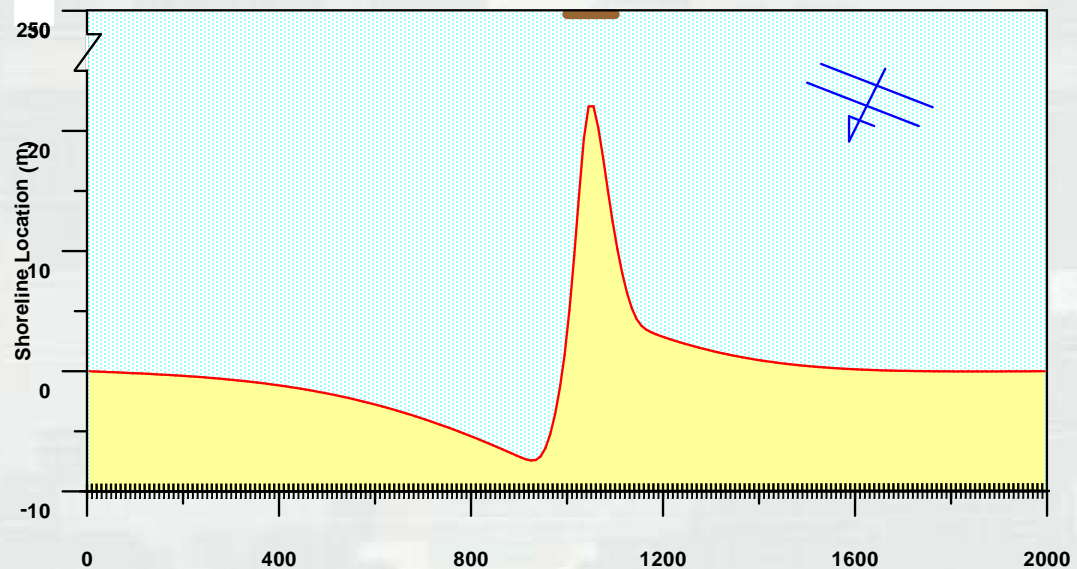
GenCade – Variable Grid Alongshore

Detached Breakwater
3-month simulation

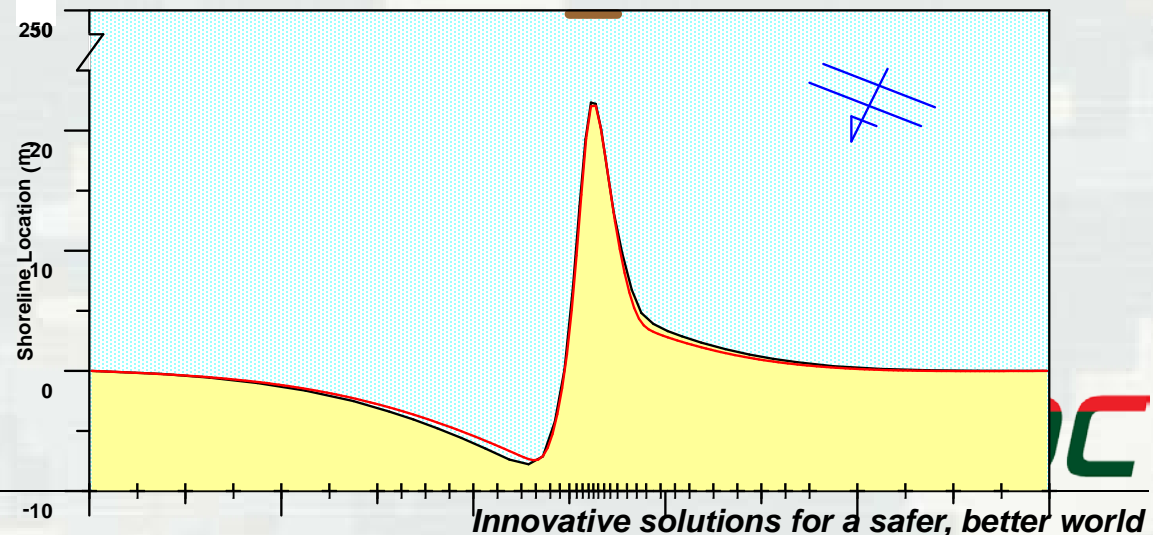
250 m offshore
100 m long

$H = 1$ m, $T = 5$ sec, $\theta = -5$ deg.

$N = 200$
 $DX = 10$ m



$N = 40$
 $DX_{\max} = 100$ m
 $DX_{\min} = 10$ m



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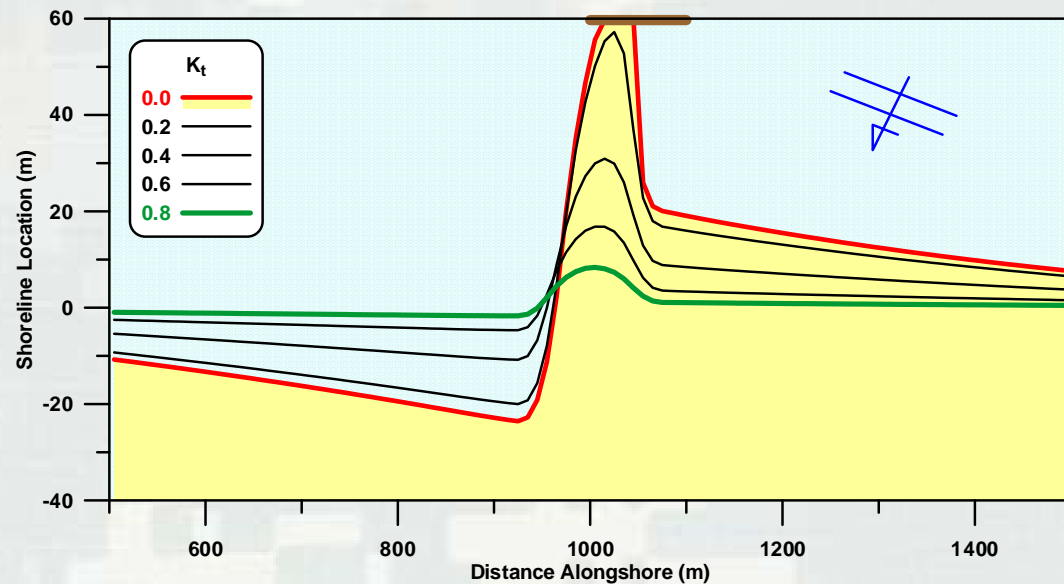
GenCade – Transmissive Breakwater

Detached Breakwater
12-month simulation

60 m offshore
100 m long

$H = 1$ m, $T = 5$ sec, $\theta = -5$ deg.

$N = 200$
 $DX = 10$ m



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<http://cirp.usace.army.mil/wiki/GenCade>
<http://cirp.usace.army.mil/products>



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